Tree Canopy Cover in Christchurch, New Zealand

Report prepared for the Christchurch City Council
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Te Whare Wānanga o Waitaha

Executive Summary

Tree canopy cover (TCC) is an important way of describing urban forests and is necessary to assess the ecosystem services they provide. Tree canopy cover was estimated for Christchurch, New Zealand using an object-based image analysis (OBIA) approach, supplemented with manual correction. The OBIA was based on aerial photography and LiDAR data acquired over Christchurch during the summer of 2015/2016.

Tree canopy cover in Christchurch is 15.59%, ranging from a low of 7.15% in the Hornby ward to a high of 28.83% in the Coastal ward. TCC in land owned by the Christchurch City Council is 24.78%. TCC in road catchments is 10.97%, while TCC in parks and reserves is 28.73%. Significant proportions of the study area were identified for their potential as tree planting sites, signalling the possibility of increasing tree canopy cover in Christchurch. Future work could focus on minor refinements of the tree cover classification, using TCC to inform policy and management of Christchurch's urban forest, defining a tree canopy cover goal for Christchurch, and regular monitoring of tree canopy cover changes.

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Background

The Christchurch City Council (CCC) is developing a tree and urban forest strategic planning document to guide policy and management decisions related to planted and naturally regenerating trees on public land in Christchurch, New Zealand. Understanding the extent of existing tree canopy cover in the city is integral to developing such a document. Tree canopy cover (TCC) is the total area of tree crowns projected onto the ground. It is expressed as a percentage of total ground area. TCC can help decision makers understand the extent of, and inequalities within, the urban forest.

Tree canopy cover is undoubtedly the most widely used descriptor of urban forest structure. Because of this, knowing Christchurch's 2015 tree canopy cover will allow decision makers to compare TCC in Christchurch with other cities in New Zealand and abroad. For example, Christchurch's tree canopy cover could be compared with cities in Australia, wherein Melbourne has only 13% TCC, while Hobart has 59% TCC[a]. It will also allow decision makers to monitor TCC changes in Christchurch over time to ensure desirable levels of TCC exist throughout the city.

This report provides a snapshot of tree canopy cover in Christchurch as at 5 October 2015, which corresponds to the date of the oldest aerial photography and LiDAR data that were acquired over Christchurch during the summer of 2015/2016.

[a] Jacobs, B., Mikhailovich, N., and Delaney, C. (2014) Benchmarking Australia's Urban Tree Canopy: An i-Tree Assessment, prepared for Horticulture Australia Limited by the Institute for Sustainable Futures, University of Technology Sydney

Methodology

Study Area

The study area was defined by the overlapping areas of aerial photography and LiDAR data (Figure 1). This included 15 of 16 wards, excluding only the Banks Peninsula ward. Notably, only land area was included in tree canopy cover calculations. Areas of open water were excluded from the total area.

Object-based image analysis

Tree canopy cover was mapped throughout Christchurch using an object-based image analysis (OBIA) approach. OBIA is a semi-automated image classification method that can be used to identify trees based on aerial photography and LiDAR data. Aerial photography provides spectral reflectance values in the red, green, and blue visible light wavelengths for each pixel. LiDAR point data were interpolated into a normalised digital surface model, from which height values were extracted.

OBIA first segments images into 'objects' by minimising the within-object variation in red, green, and blue spectral reflectance values, as well as height values. Once objects are established, each object is assigned to a land cover class (e.g. tree, grass, building) based on the reflectance and height values. This latter process is called classification. Critically, classification requires that spectral reflectance and height thresholds be set for each land cover class. These thresholds act as a definition for each land cover class.

Definition of a tree

For the purpose of the OBIA, a tree was defined as an object having vegetation-like reflectance characteristics, exceeding 3.5 m in height and having a minimum diameter of 1. 5 m. Remote sensing analyses, like this one, are constrained by the available data and thus must use a definition based on spectral reflectance and structure of objects, rather than a biologically acceptable definition of a tree.

The thresholds of 3.5 m height and 1.5 m diameter were selected for three purposes. Firstly, the ecosystem services provided by trees generally increase with tree size, so including smaller trees in this analysis would not contribute further to an understanding of the ecosystem services provided by Christchurch's urban forest. Secondly, reducing these thresholds would decrease the accuracy of the tree cover classification by introducing error associated with other shorter, similarly-sized objects (e.g. vehicles, garden sheds, fences, etc.). Thirdly, the nominal spatial resolution of the aerial photography and, especially, the LiDAR data preclude reducing these thresholds significantly.

All tree cover areas reported below are inclusive of all tree and forest types, unless otherwise stated. This includes, but is not limited to, park and reserve trees, street trees, trees on private property, orchards, remnant patches of native forest, hedgerows, and trees in commercially-managed, large-scale forestry plantations.

Manual refinement of OBIA

Following the OBIA, tree canopy cover was manually refined to correct errors in the tree cover classification. The study area was overlaid with a grid corresponding to aerial photography tile boundaries. Each grid cell was iterated through and objects within each cell were manually edited where misclassifications occurred. Objects resulting from errors of commission (objects that were classified as trees, but should not have been) were deleted, while objects resulting from errors of omission (objects that were not classified as trees, but should have been) were reclassified as trees. Manual corrections were undertaken at a scale of 1:1,500. At this scale, relatively large misclassified objects (the size of a house or large tree) are more likely to be identified and corrected than smaller misclassified objects.

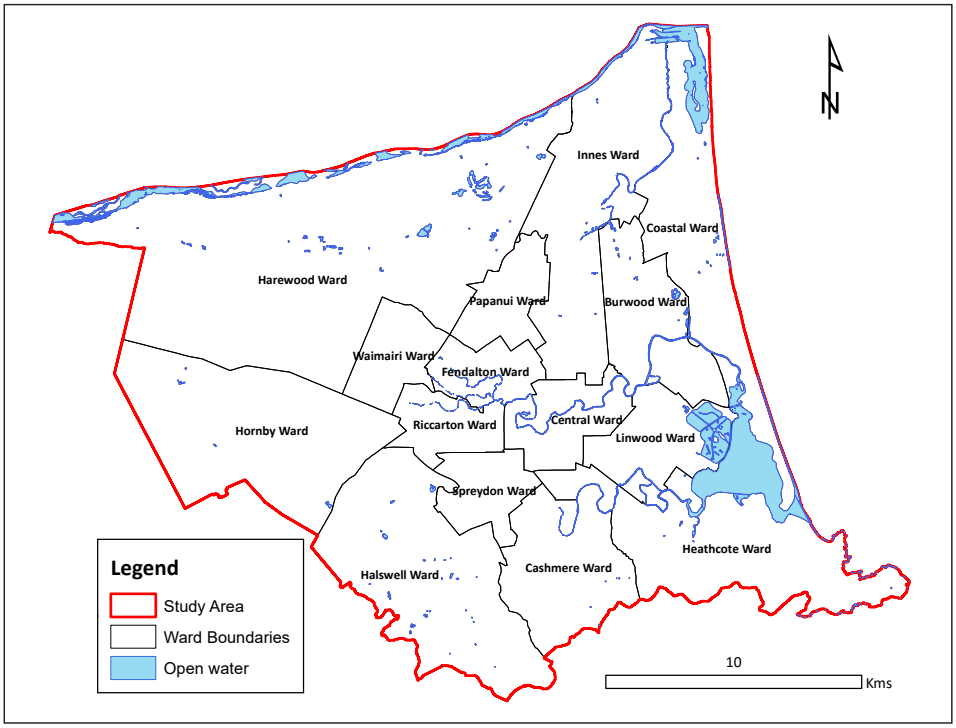

Figure 1 – The study area and ward boundaries used to determine tree canopy cover in this study.

Imagery used in the analysis

Aerial photography was captured by AAM NZ Ltd. for the Christchurch City Council during the summer of 2015/2016. Data were acquired over the Christchurch City CBD on 17 Nov 2015 and the surrounding parts of Christchurch City and Banks Peninsula were captured on 22 January, 10 & 20 February 2016. LiDAR data were captured for Environment Canterbury Regional Council by AAM NZ Ltd. between 5 October and 7 November 2015.

Ancillary boundaries used in the analysis

In order to produce tree canopy cover estimates (see Results below), boundaries for areas of interest were needed. As described in the Study Area section above, only land areas within Christchurch were considered. Open water was excluded from the study area using pond, river, and lake polygons from the NZ Topo50 map series. The boundary for land owned by the CCC was sourced from the CCC and is derived from their valuation/rating system. Plantation forest boundaries were modified from the same valuation/rating boundaries, or were sourced from the forest managers themselves. Ward boundaries, road catchment boundaries and park boundaries were obtained from the Christchurch District Plan.

Accuracy Assessment

The quality of the tree canopy cover map was determined by means of a formal accuracy assessment. The accuracy assessment uses a standardised approach, comparing what has been mapped as tree canopy cover with what actually exists in the aerial photographs. One thousand sample points were randomly distributed within the study area and each of these was assigned a 'reference' land cover based on what was observed at the location defined by each point in the aerial photography. The 'reference' land cover is the true land cover. Each point was also assigned a 'classified' land cover based on what was mapped by the OBIA at the location defined by each point.

The result of the accuracy assessment is an error matrix that quantifies the overall accuracy of the OBIA classification as well as the errors of commission (land that was classified as tree cover, but shouldn't have been) and errors of omission (land that was not classified as tree cover, but should have been) (Table 8).

Potential Planting Sites

To set expectations for potential tree canopy cover in Christchurch, a measure of current tree canopy cover needs to be accompanied by an estimate for the proportion of land that could be considered as potential tree planting sites. Previous research has established a robust method for achieving this result[2]. Modifying these methods for this study resulted in 1000 sample points being placed randomly throughout the study area. Each of these sample points was described as either being suitable or unsuitable as a potential planting site, based on the following criteria:

1. land cover is grass, dry grass, or bare soil;
2. the tree's trunk does not overlap a sports field, nor a grave site;
3. the tree's trunk is no closer than 0.6 m from any impervious surface, including pavements and buildings;
4. the minimum available pervious area (e.g. grass, dry grass, bare soil) is 1.5 m[b];
5. there is no crown overlap with existing trees (all potential trees were assumed to have a crown diameter of 4.6 m).

[b] Wu, C., et al. (2008). "A method for locating potential tree-planting sites in urban areas: A case study of Los Angeles, USA." Urban Forestry & Urban Greening 7(2): 65–76.

Results

City-wide tree cover

The study area covers 43,224.93 hectares (ha) or 432.25 km^2 of land, of which 15.59% (6,738.51 ha or 67.39 km^2) is covered by tree canopy (Figure 2). Areas of large-scale, commercially-managed plantation forest exist within the study area. These areas are easily identified in the northwest, northeast and southern extents of the study area (Figure 2). Though they currently contribute to Christchurch's tree canopy cover, these forests are prone to harvesting, deforestation, pests and disease, or fire. With that in mind, their lasting contribution to tree cover is uncertain, and so it may be undesirable to include them in tree canopy cover estimates. If large-scale plantation forests are excluded, tree canopy cover within the study area decreases to 11.60% (5,014.58 ha or 50.15 km^2).

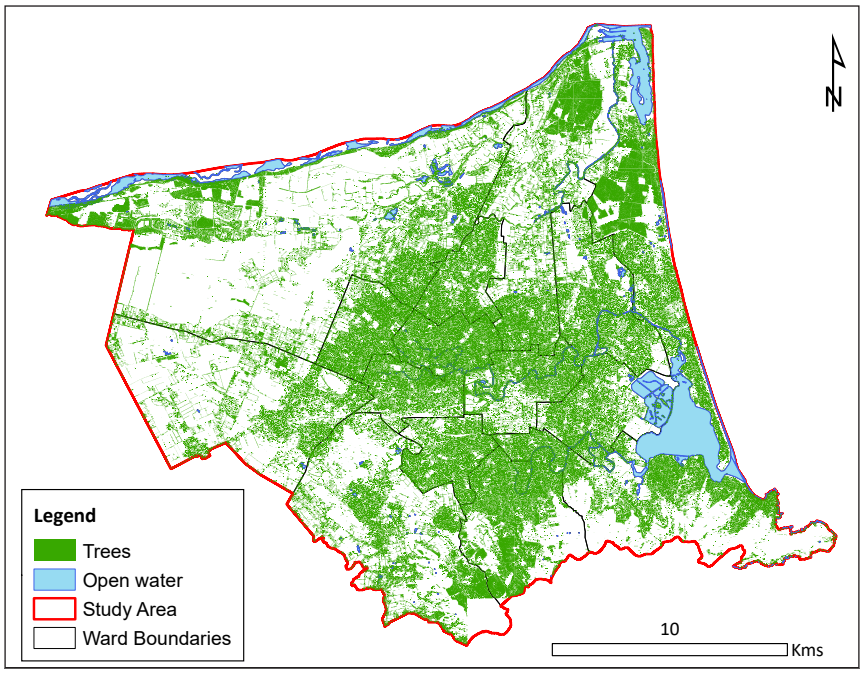

Figure 2 – Tree cover in Christchurch. Tree cover appears exaggerated at smaller scales, as in this figure. Zooming in to a larger scale will show finer detail and give a more accurate representation of tree cover.

Ward by ward tree cover

Tree canopy cover is highly variable within Christchurch's 15 wards (Table 1). The three wards with the highest tree canopy cover are: (1) the Coastal ward (28.83%); (2) Cashmere (28.42%); and (3) Fendalton (22.71%). The three wards with the lowest tree canopy cover are: (1) Hornby (7.15%); (2) Linwood (11.22%), and Heathcote (11.35%).

Tree cover values in Cashmere, Coastal, Halswell, Harewood, and Innes wards are inflated by areas of large-scale, commercially-managed plantation forest (Table 1, Figure 3). If large-scale plantation forests are excluded, tree cover in these wards decreases markedly to values that are more aligned with surrounding wards. For example, the Innes Ward has 22.15% tree cover, inclusive of large-scale plantation forests. But, excluding these plantations decreases tree cover to 11.81%, which is comparable to the tree cover in Burwood (12.51%) and Papanui (13.03%), both of which border the Innes Ward. With some exceptions, tree cover, excluding plantations, appears to decrease moving outwards from the Central ward (Figure 3).

*Table 1 – Tree canopy cover description within Christchurch's wards. Tree cover areas are reported inclusive and exclusive of large-scale plantation forests. * indicates wards with significant areas of large-scale plantation forest.*

Ward Name	Ward Area (ha)	Tree Cover (ha) - inclusive	Tree Cover (%) - inclusive	Tree Cover (ha) – exclusive	Tree Cover (%) - exclusive
Burwood	2,018.64	252.59	12.51	252.59	12.51
Cashmere*	2,386.04	678.16	28.42	441.69	18.51
Central	1,305.16	222.51	17.05	222.51	17.05
Coastal*	3,032.13	874.31	28.83	346.46	11.43
Fendalton	905.09	205.58	22.71	205.58	22.71
Halswell*	4,610.67	591.31	12.82	482.09	10.46
Harewood*	10,953.3	1,478.20	13.50	1,048.16	9.57
Heathcote	3,791.11	430.41	11.35	430.41	11.35
Hornby	4,667.74	333.88	7.15	333.88	7.15
Innes*	4,064.65	900.21	22.15	479.86	11.81
Linwood	1,424.79	159.93	11.22	159.93	11.22
Papanui	1,049.92	136.78	13.03	136.78	13.03
Riccarton	960.96	163.12	16.97	163.12	16.97
Spreydon	1,007.53	141.09	14.00	141.09	14.00
Waimairi	1,047.20	170.43	16.27	170.43	16.27
Total	**43,224.93**	**6,738.51**	**15.59**	**5,014.58**	**11.60**

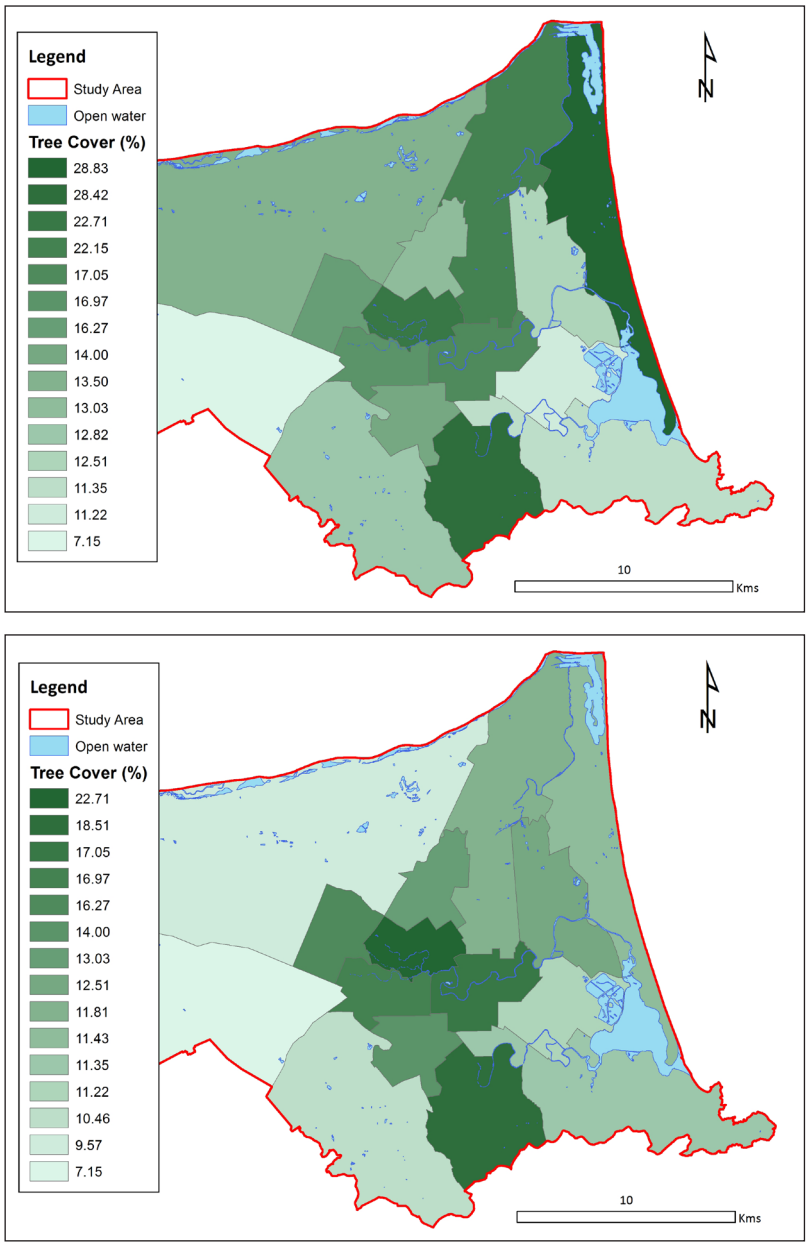

Figure 3 – Ward-by-Ward tree cover, including (top) and excluding (bottom) large-scale, commercially-managed plantation forests. Darker green colours represent wards with higher tree cover.

Table 2 – Tree canopy cover description within Christchurch's road catchments.

Road Type	Road Catchment Area (ha)	Tree Cover (ha)	Tree Cover (%)
Collector	677.53	69.70	10.29
Local Road	2,128.65	243.45	11.44
Major Arterial	518.78	51.53	9.93
Minor Arterial	430.80	47.43	11.01
Motorway	3.24	0.0012	0.04
Pedestrian	1.08	0.19	17.59
Private	79.87	8.99	11.26
Total	**3,839.95**	**421.29**	**10.97**

Tree cover in other areas of interest

All tree cover areas reported below are inclusive of all tree and forest types, unless otherwise stated. This includes, but is not limited to, park and reserve trees, street trees, trees on private property, orchards, remnant patches of native forest, hedgerows, and trees in commercially-managed, large-scale forestry plantations.

Tree cover within land owned by the Christchurch City Council

The total area of land within the study area that is owned by the Christchurch City Council is 6,827.17 ha or 68.27 km^2, of which 24.78% (1,691.66 ha or 16.92 km^2) is covered by tree canopy. Tree cover area on CCC-owned land comprises 25.1% of the total tree cover in Christchurch.

Tree cover outside land owned by the Christchurch City Council

The total area of land within the study area that is not owned by the Christchurch City Council is 38,271.73 ha or 382.72 km^2, of which 13.14% (5,030.38 ha or 50.30 km^2) is covered by tree canopy. Tree cover on land not owned by the CCC comprises 74.9% of the total tree cover in Christchurch.

Tree cover in Christchurch's road catchments

The total area of road catchments within the study area is 3,839.95 ha or 38.40 km^2, of which 10.97% (421.29 ha or 4.21 km^2) is covered by tree canopy. Tree cover area within road catchments comprises 6.25% of the total tree cover in Christchurch. Tree canopy cover is generally consistent across different road catchment types, but is lowest within motorway catchments and highest within pedestrian road type catchments (Table 2) – it should be noted both these road catchment types represent very small areas.

Looking at tree cover within road catchments across Christchurch's wards yields high levels of variation. Hornby has the lowest tree canopy cover (5.42%) within its road catchments, while Cashmere has the highest tree canopy cover within its road catchments (23.59%) (Table 3).

Looking at tree canopy cover within different road classes on a ward-by-ward basis also shows a high level of variability (Table 4):

- Tree cover in **collectors** ranges from 5.99% in Halswell to 19.04% in Innes (all wards have collectors)
- Tree cover in **local roads** ranges from 4.5% in Riccarton to 26.95% in the Coastal ward (all wards have local roads)
- Tree cover in **major arterials** ranges from 4.37% in Fendalton to 20.08% in Waimairi (1 of 15 wards had no major arterials)
- Tree cover in **minor arterials** ranges from 5.31% in Halswell to 22.34% in Burwood (all wards have minor arterials)
- Only Spreydon has a **motorway**, which has 0.04% tree cover
- Only Central and Halswell wards have **pedestrian** roads, which are 17.68% and 11.56% covered by trees, respectively
- Tree cover in **private roads** ranges from 2.48% in the Coastal ward to 29.11% in Spreydon (all wards have private roads)

Table 3 – Tree canopy cover description within Christchurch's road catchments, broken down on a ward-by-ward basis.

Ward Name	Road Catchment Area (ha)	Tree Cover (ha)	Tree Cover (%)
Burwood	288.69	21.78	7.54
Cashmere	201.71	47.58	23.59
Central	288.74	36.14	12.52
Coastal	251.71	13.79	5.48
Fendalton	150.77	24.30	16.12
Halswell	410.23	25.22	6.15
Harewood	386.51	37.14	9.61
Heathcote	367.31	52.67	14.34
Hornby	317.50	17.20	5.42
Innes	290.70	43.90	15.10
Linwood	223.21	20.59	9.23
Papanui	159.53	18.17	11.39
Riccarton	156.62	20.26	12.94
Spreydon	192.00	17.89	9.32
Waimairi	154.75	24.64	15.92

Table 4 - Tree canopy cover description within Christchurch's road catchments, broken down by road catchment type and ward. Table continues on page 9.

	Collector			Local Road			Major Arterial		
Ward Name	Road Catchment Area (ha)	Tree Cover (ha)	Tree Cover (%)	Road Catchment Area (ha)	Tree Cover (ha)	Tree Cover (%)	Road Catchment Area (ha)	Tree Cover (ha)	Tree Cover (%)
Burwood	39.49	3.52	8.92	185.48	13.27	7.16	26.53	2.03	7.67
Cashmere	31.93	3.90	12.20	127.18	34.28	26.95	0	0	-
Central	53.10	4.35	8.19	133.96	17.26	12.88	44.56	6.58	14.78
Coastal	78.50	5.18	6.60	153.83	7.44	4.84	7.17	0.42	5.86
Fendalton	23.63	3.41	14.42	92.55	14.84	16.04	10.66	2.14	20.08
Halswell	69.02	4.14	5.99	227.70	14.77	6.49	72.44	3.16	4.37
Harewood	72.12	9.08	12.60	199.87	21.64	10.83	58.16	2.86	4.91
Heathcote	69.59	8.40	12.07	188.03	27.34	14.54	61.72	11.22	18.18
Hornby	53.20	3.89	7.32	161.72	7.27	4.50	57.50	2.95	5.12
Innes	63.93	12.17	19.04	140.25	21.93	15.63	34.19	3.28	9.58
Linwood	29.42	1.99	6.78	132.54	12.09	9.12	45.23	5.43	12.01
Papanui	24.66	2.41	9.76	98.36	12.34	12.55	16.99	1.56	9.20
Riccarton	19.56	1.95	9.95	85.83	11.94	13.92	23.85	2.73	11.47
Spreydon	15.03	1.13	7.49	106.44	10.73	10.08	42.31	4.42	10.44
Waimairi	34.34	4.19	12.19	94.93	16.30	17.17	17.48	2.74	15.66

Tree cover in parks and reserves

The total area of parks and reserves within the study area is 6,098.57 hectares (ha) or 60.99 km^2, of which 28.73% (1,752.40 ha or 17.52 km^2) is covered by tree canopy. Trees in parks and reserves are an important contributor to Christchurch's urban forest, comprising 26% of Christchurch's total tree cover. This is especially true in areas with otherwise low tree canopy cover (Figure 4). Tree canopy cover varies across different park types, ranging from 19.23% in sports parks to 53.24% in garden & heritage parks (Table 5).

Table 5 – Tree canopy cover description within Christchurch's parks and reserves.

Park Type	Park Area (ha)	Tree Cover (ha)	Tree Cover (%)
Cemetery	75.73	14.99	19.79
Garden & Heritage	80.05	42.62	53.24
Local & Community Park	654.03	148.71	22.74
Regional Park	4,083.64	1,314.35	32.19
Sports Park	1,205.12	231.72	19.23
Total	**6,098.57**	**1,752.40**	**28.73**

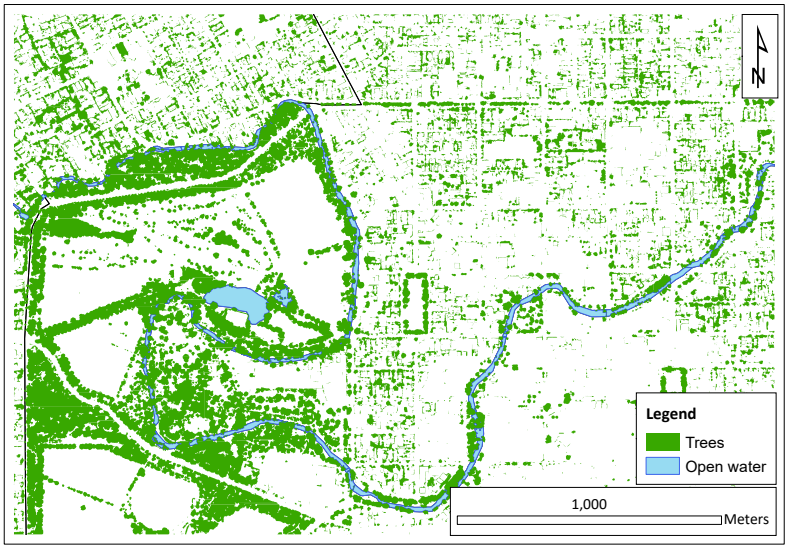

Figure 4 – Tree canopy cover in Hagley Park is a major contributor to the overall tree canopy cover in the central ward. Parks and reserves play an important role for maintaining and enhancing tree cover in areas where tree cover is low.

Minor Arterial			Motorway			Pedestrian			Private		
Road Catchment Area (ha)	Tree Cover (ha)	Tree Cover (%)	Road Catchment Area (ha)	Tree Cover (ha)	Tree Cover (%)	Road Catchment Area (ha)	Tree Cover (ha)	Tree Cover (%)	Road Catchment Area (ha)	Tree Cover (ha)	Tree Cover (%)
34.34	2.74	7.99	0	0	-	0	0	-	2.86	0.20	7.13
35.73	7.98	22.34	0	0	-	0	0	-	6.86	1.42	20.74
53.91	7.58	14.07	0	0	-	1.07	0.19	17.68	2.13	0.17	7.91
8.53	0.45	5.31	0	0	-	0	0	-	3.68	0.29	8.01
23.02	3.65	15.84	0	0	-	0	0	-	0.91	0.27	29.11
34.90	2.70	7.73	0	0	-	0.01	0.00	11.56	6.16	0.45	7.32
35.35	2.63	7.43	0	0	-	0	0	-	21.03	0.93	4.44
34.49	2.89	8.37	0	0	-	0	0	-	13.47	2.82	20.96
37.89	2.91	7.68	0	0	-	0	0	-	7.19	0.18	2.48
50.27	6.26	12.44	0	0	-	0	0	-	2.06	0.27	13.17
12.58	0.83	6.61	0	0	-	0	0	-	3.45	0.25	7.24
17.58	1.64	9.32	0	0	-	0	0	-	1.94	0.22	11.39
23.28	2.59	11.13	0	0	-	0	0	-	4.10	1.04	25.48
21.71	1.26	5.80	3.24	0.00	0.04	0	0	-	3.27	0.36	11.08
7.23	1.32	18.31	0	0	-	0	0	-	0.76	0.10	12.81

Looking at tree cover within park types across Christchurch's wards yields high levels of variation. Heathcote has the lowest tree canopy cover (6.0%) within its park types, while Innes has the highest tree canopy cover within its parks (64.6%) (Table 6).

Table 6 – Tree canopy cover description within Christchurch's park types, broken down on a ward-by-ward basis.

Ward Name	Park Area (ha)	Tree Cover (ha)	Tree Cover (%)
Burwood	320.79	58.36	18.2
Cashmere	446.75	113.23	25.3
Central	227.82	92.25	40.5
Coastal	1,676.45	720.68	43.0
Fendalton	33.28	12.07	36.3
Halswell	430.03	43.10	10.0
Harewood	443.21	83.39	18.8
Heathcote	1,266.37	76.00	6.0
Hornby	211.11	32.03	15.2
Innes	645.85	417.47	64.6
Linwood	151.29	33.17	21.9
Papanui	53.42	13.12	24.6
Riccarton	35.51	18.86	53.1
Spreydon	57.81	16.08	27.8
Waimairi	96.60	22.60	23.4

Looking at tree canopy cover within different park types on a ward-by-ward basis also shows a high level of variability (Table 7):

- Tree cover in **cemeteries** ranges from 12.05% in Cashmere to 51.72% in Innes (9 of 15 wards have no cemeteries)
- Tree cover in **garden and heritage parks** ranges from 33.63% in Hornby to 76.61% in Papanui (3 of 15 wards have no garden and heritage parks)
- Tree cover in **local community parks** ranges from 10.41% in Halswell to 67.65% in Riccarton (all wards have local community parks)
- Tree cover in **regional parks** ranges from 3.33% in Heathcote to 71.23% in Innes (6 of 15 wards have no regional parks)
- Tree cover in **sports parks** ranges from 7.64% in Halswell to 36.1% in the Central ward (all wards have sports parks)

Table 7 – Tree canopy cover description within Christchurch's parks and reserves, broken down on a ward-by-ward basis.

	Cemetery			Garden and Heritage			Local Community Park			Regional Park			Sports Park		
Ward Name	Park Area (ha)	Tree Cover (ha)	Tree Cover (%)	Park Area (ha)	Tree Cover (ha)	Tree Cover (%)	Park Area (ha)	Tree Cover (ha)	Tree Cover (%)	Park Area (ha)	Tree Cover (ha)	Tree Cover (%)	Park Area (ha)	Tree Cover (ha)	Tree Cover (%)
Burwood	0	0	-	0	0	-	58.21	9.15	15.72	147.25	35.08	23.83	115.33	14.12	12.25
Cashmere	5.31	0.64	12.05	5.28	3.46	65.47	33.10	16.67	50.35	393.53	90.26	22.94	9.52	2.20	23.11
Central	0	0	-	43.94	24.38	55.48	20.89	9.03	43.24	0	0	-	162.99	58.84	36.10
Coastal	0	0	-	0	0	-	51.08	6.70	13.12	1457.49	681.08	46.73	167.88	32.90	19.60
Fendalton	0	0	-	3.33	2.06	61.89	4.48	1.88	41.94	0	0	-	25.47	8.14	31.94
Halswell	0.30	0.05	16.18	0.09	0	0	161.98	16.86	10.41	66.39	10.82	16.29	201.27	15.38	7.64
Harewood	0	0	-	11.72	4.35	37.09	50.81	14.82	29.16	337.73	55.83	16.53	42.94	8.39	19.54
Heathcote	0	0	-	4.15	1.99	47.89	103.23	25.75	24.94	1106.48	36.79	3.33	52.51	11.47	21.84
Hornby	4.28	1.27	29.62	1.55	0.52	33.63	49.00	5.50	11.23	0	0	-	156.29	24.74	15.83
Innes	2.10	1.08	51.72	0	0	-	20.26	3.49	17.24	565.96	403.13	71.23	57.54	9.76	16.96
Linwood	51.79	8.10	15.64	1.61	0.92	56.93	25.75	7.95	30.89	8.50	1.33	15.70	63.65	14.87	23.36
Papanui	0	0	-	0.11	0.08	76.61	25.95	6.90	26.58	0.08	0.02	27.56	27.28	6.11	22.41
Riccarton	0	0	-	4.34	2.37	54.57	20.99	14.20	67.65	0	0	-	10.18	2.30	22.56
Spreydon	0	0	-	1.77	0.96	54.00	15.03	5.72	38.06	0	0	-	41.01	9.40	22.93
Waimairi	11.96	3.85	32.23	2.17	1.55	71.40	13.25	4.09	30.89	0	0	-	69.23	13.10	18.93

Accuracy of tree cover classification

The error matrix shown in Table 8 shows that the OBIA classified land covers with an overall accuracy of 98.8%.

Table 8 – The error matrix showing the results of the classification accuracy assessment.

		Classified land cover		Producer's Accuracy
		Tree cover	Other land cover	
Reference land cover	Tree cover	169	4	97.77%
	Other land cover	8	819	99.03%
	User's Accuracy	95.48%	99.51%	

- Overall Accuracy = 98.8%
- Commission Error (Trees) = 1 – User's Accuracy = 4.52%
- Omission Error (Trees) = 1 – Producer's accuracy = 2.23%

For a definition of these terms, see the Glossary

Tree canopy cover classification achieved a high accuracy (Producer's accuracy – 97.77%, User's accuracy = 95.48%), with a tendency for a slight over-classification. This is confirmed by the commission error rate (4.52%) being slightly higher than the omission error rate (2.23%). What this means is that the total area of tree canopy cover is likely to be a small over-estimate.

Potential Tree Planting Sites – an initial analysis

To explore Christchurch's potential to increase tree canopy cover, it was necessary to assess potential tree planting sites. Within the entire study site, 523 of the 1000 sample points (52.3%) were on land that that met the criteria for potential planting sites. If we consider only sample points that were on land owned by the CCC, 84 of 151 points (55.6%) met the criteria for potential planting sites.

It is important to note the caveats that accompany these initial potential planting site estimates:

- There is error associated with the estimates, because they are based on randomly placed sample points.
  - The 95% confidence interval for the entire study site is 50.7% – 53.9%.
  - The 95% confidence interval for land owned by the CCC is 51.6% – 59.7%

A 95% confidence interval means that if a different set of 1000 sample points were assessed, there is a 95% chance that the percentage of potential planting sites would be between the stated upper and lower limits.

- The estimates are overestimates because:
  - it assumes that any grass, dry grass, or bare soil site can be planted with trees, which is not true because:
    - current or future land use may not be compatible with trees (e.g. pasture or grassland)
    - areas of ecological significance are included (e.g. tussock grasslands should not be planted with trees)
  - it assumes newly planted trees will have a maximum crown diameter of 4.6 m. This was done for simplicity and represents only a realistic maximum crown diameter for small trees.

Despite these caveats, the potential planting site estimates are important because they help to establish a theoretical upper limit for the tree canopy cover in Christchurch. This is illustrated with two scenarios below.

Scenario 1 – Tree planting only within CCC-owned land

If we consider the possibility of planting trees on only council owned land, 55.6% of the 6,827.17 ha owned by CCC is potentially plantable. This represents a potential to plant an additional 3,795.9 ha of tree cover on CCC owned land. Adding this value to the existing city-wide tree cover measurement, increases tree cover from 6,738.51 ha to 10,534.41 ha, or 24.37%.

Scenario 2 – Tree planting throughout all of Christchurch

If we consider the possibility of planting trees on all land within the study area, 52.3% of the 43,224.93 ha study area is potentially plantable. This represents a potential to plant an additional 22,606.64 ha of tree cover within the study area. Adding this value to the existing city-wide tree cover measurement increases tree cover from 6,738.51 ha to 29,345.15 ha, or 67.89%.

Concluding remarks on potential tree planting sites

A more robust analysis of potential planting sites could minimise the disparity in the estimates highlighted by the two scenarios, by addressing the caveats listed above. In doing so, future efforts could provide a more realistic tree canopy cover goal for Christchurch, rather than the theoretical upper limits associated with both scenarios described above. Moreover, future analysis could identify the locations of potential planting sites, unlike this aspatial statistical analysis.

Summary of key results

This report has identified a number of key results that will help The Christchurch City Council develop a tree and urban forest strategic planning document. These include:

- 15.59% of all land in Christchurch is covered by trees
  - Forest plantations comprise a significant portion of Christchurch's tree cover
  - Large proportions of the study area were identified as potential tree planting sites, demonstrating the possibility of significantly increasing tree cover in Christchurch
- 24.78% of the land owned by the CCC is covered by trees
- 13.14% of the land not owned by the CCC is covered by trees
- 10.97% of the land within Christchurch's road catchments is covered by trees
- 28.73% of the land within Christchurch's parks and reserves is covered by trees

Next Steps

This canopy cover assessment should be considered as the first step towards improving the policy and strategic management of Christchurch's urban forest. Future work could include:

- **Manual editing**
  As evidenced by the accuracy assessment, there are small errors in the tree cover classification. These errors can only be corrected via further manual editing. Depending on future uses of this data, manual correction may be desirable or necessary.

- **TCC comparison**
  Tree canopy cover in Christchurch could be compared with relevant cities worldwide. Knowing what tree cover is in cities with comparable characteristics (e.g. climate, population), could help Christchurch set tree canopy cover targets.

- **TCC comparison within Christchurch**
  Comparing tree canopy cover across different wards (or other spatial units of interest) could lead to prioritising planting programs in wards with low tree canopy cover, or prioritising tree maintenance budgets in wards with high tree cover.

- **Determining Christchurch's potential tree cover increase**
  By quantifying available planting space within Christchurch that is not currently covered by trees, it is possible to determine the maximum potential tree canopy cover. This will help in establishing achievable tree canopy cover goals. Though an initial assessment is provided herein, a more robust measurement would help determine a more realistic tree canopy cover goal, rather than the theoretical upper limit for tree canopy cover in Christchurch.

- **Quantifying tree species diversity**
  Understanding tree species diversity is used by many councils globally to inform planting strategy and to mitigate risk from climate change, pests, or disease.

- **Regular monitoring**
  Tree canopy cover should continue to be monitored regularly. Using an approach comparable to that undertaken in this report relies on the regular acquisition of aerial photography and LiDAR. Should aerial photography and LiDAR be unavailable in the future, a ground-based approach (e.g. using a NZ version of i-Tree) could be employed. Regularly monitoring of changes in tree cover can help to assess whether current policies/management are effective, and inform future policies/management.

Glossary

Object-based image analysis: a method for automatically classifying remotely-sensed imagery (e.g. aerial photography, LiDAR data) into land covers of interest (e.g. trees, buildings, roads, grasslands). Imagery is segmented into 'objects' (based on minimising the within-object variation in spectral or other characteristics). Objects are then classified as a land cover of interest.

Commission error: objects that were classified as a particular land cover (e.g. tree), but should not have been (e.g. the object was actually a building). Commission errors are calculated separately for each land cover class. See figure below for an example.

Omission error: objects that were not classified as a particular land cover, but should have been. For example, a tree in the imagery was not classified as a tree, but instead as a building. Omission errors are calculated separately for each land cover class. See figure below for an example.

From the perspective of tree cover accuracy, the image at left shows a commission error – an object that is not a tree (it is a building) has been classified as a tree. The image at right shows an omission error – an object that is a tree has not been classified as a tree, it has been classified as a building.

95% confidence interval: a range of values defining an upper and lower limit, such that there is a 95% probability that the value of a parameter lies within it.

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